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Prevalence of Dengue Serological Markers among Febrile Patients at Centre de Recherche Biomoléculaire Pietro Annigoni (CERBA), Burkina Faso

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Abstract

Dengue virus infection is a major public health concern in endemic regions, including Burkina Faso, where data on seroprevalence and progression are limited. This study aimed to evaluate the seroprevalence and dynamics of dengue virus infection among suspected febrile patients at CERBA. A descriptive analytical study was conducted from January to September 2023, including 4484 patients who underwent dengue serological testing. Venous blood samples were processed to detect NS1 Ag, IgM, and IgG antibodies using the SD Bioline Dengue Duo Rapid Detection Kit. Data were analyzed with SPSS v26.0 using multivariate logistic regression, with statistical significance set at $p < 0.05$. The study population comprised 60.1% females and 39.9% males, with a mean age of 26.80 ± 16.24 years. Dengue seroprevalence was 57.5%, with 37.9% NS1 Ag^+, 18.2% IgM^+, and 36.8% IgG^+. NS1 Ag positivity was highest in the 16 - 30 age group (57.3%), while IgG positivity peaked in individuals aged > 46 years. September recorded 83.5% of suspected cases, with 54.5% NS1 Ag positivity. Multinomial regression revealed that individuals aged 16 - 30 were significantly more likely to test positive for NS1 Ag (OR = 1.487, p = 0.002) compared to children under five years, while those > 65 years were less likely (OR = 0.517, p = 0.005). This study highlights the high dengue seroprevalence among suspected febrile cases in Ouagadougou, with significant age-related variability and

seasonal trends, emphasizing the need for targeted surveillance and preventive measures.

Keywords

NS1 Antigen, IgM, IgG, Febrile Patients, Burkina Faso

1. Introduction

Dengue fever, a mosquito-borne viral disease, continues to pose a significant public health challenge worldwide, particularly in tropical and subtropical regions [1]. Globally, dengue has emerged as the most prevalent arboviral infection [2]. According to the World Health Organization (WHO), reported dengue cases surged from 505,430 cases in 2000 to 5.2 million in 2019 [3]. The year 2023 marked a historic high in dengue cases, with over 6.5 million cases and more than 7,300 dengue-related deaths reported globally [3].

Africa has experienced an increasing number of dengue outbreaks in recent years, reflecting the expanding geographical range of the disease [2]. In Burkina Faso, the 2023 dengue outbreak underscored the severity of the disease, with widespread cases and considerable morbidity [4]-[6]. Dengue has become endemic in Burkina Faso, with periodic outbreaks marked by fluctuating serotype dominance. The 2023 outbreak was particularly notable for a serotype switch from DENV-1 to DENV-3, a phenomenon linked to changes in viral dynamics and population immunity [6]-[8]. This outbreak highlighted the urgent need for robust surveillance systems and effective intervention strategies to mitigate the impact of dengue in the country [9] [10].

The disease is caused by the dengue virus (DENV), a member of the Flavivirus genus, with four distinct serotypes (DENV-1 to DENV-4). Infection with one serotype provides lifelong immunity to that serotype but only temporary and partial immunity to the others, leading to the risk of severe disease upon secondary infections [11]-[13]. Dengue fever presents with a wide spectrum of clinical manifestations, ranging from asymptomatic infection and mild febrile illness to severe forms such as Dengue Hemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS), both of which are associated with significant mortality if untreated [13].

The diagnosis of dengue relies on various methods, including molecular techniques like RT-PCR and serological tests such as Enzyme-Linked Immunosorbent Assays (ELISA) to detect NS1 antigen, IgM, and IgG antibodies [14]. Among these, serological markers remain crucial for confirming cases in resource-limited settings, where molecular methods may not be widely accessible.

Considering the recurrent outbreaks and the associated public health burden, this study aims to investigate the prevalence and temporal patterns of dengue serological markers among suspected febrile cases seen at Centre de Recherche Biomoléculaire Pietro Annigoni (CERBA) from January to September 2023.

2. Materials and Methods

2.1. Type and Period of Study

This descriptive analytical study assessed the seroprevalence and progression of dengue virus infection among patients at CERBA over a 9-month period, from 1 January to 30 September 2023.

2.2. Study Population

A total of 4,484 patients seen at or referred to the CERBA laboratory for dengue serological testing during the study period were consecutively enrolled, regardless of age, sex, origin or ethnic group.

2.3. Eligibility Criteria

Patients were eligible if they presented with febrile illness and clinical suspicion of dengue as indicated by the referring physician. Individuals with incomplete clinical or demographic information, or those whose serum samples were insufficient or inadequate for testing, were excluded from the study.

2.4. Sample Collection

Venous blood samples were collected in either dry tubes or EDTA tubes. Following centrifugation at 4,000 rpm for 5 minutes, serum or plasma was extracted and used for dengue testing. Serological tests were conducted immediately after sample collection to ensure prompt availability of results.

2.5. Diagnosis of Dengue Virus Infection

Dengue virus infection was diagnosed using the SD Bioline Dengue Duo Rapid Detection Kit (Standard Diagnostics Inc., Korea), following the manufacturer's instructions. This rapid test detects the NS1 antigen and anti-dengue virus IgG/IgM antibodies in serum, plasma, or whole blood. According to the manufacturer, the assay has a sensitivity of 92.4% for NS1 antigen and 94.2% for IgG/IgM antibodies, with specificities of 98.4% for NS1 antigen and 96.4% for IgG/IgM antibodies. These performance characteristics indicate high diagnostic accuracy and support the reliability of the results obtained in this study.

2.6. Data Analysis

Data were processed using Microsoft Excel version 2019 and Statistical Package for Social Sciences (SPSS) version 26.0 (SPSS Inc., Chicago, IL, USA). Multivariate logistic regression was used to assess the effects of age and gender on dengue infection. Statistical differences were deemed significant at $p < 0.05$.

3. Results

The study included 4,484 febrile patients of various ages and sexes who attended general medical consultations and were referred to the CERBA laboratory for den-

gue serological testing during the study period.

3.1. Sociodemographic Characteristics of the Study Population

The study population comprised 60.1% females (2693/4484) and 39.9% males (1791/4484). The mean age was 26.80 ± 16.24 years (range: 0 - 93 years) overall, with 27.75 ± 15.86 years (range: 0 - 90 years) in females and 25.38 ± 16.70 years (range: 0 - 93 years) in males. The age group 16 - 30 years was the most represented, accounting for 41.6% (1864/4484) of the study population (Table 1).

Table 1. Sociodemographic characteristics and prevalence of dengue in the study population.

Characteristics	Serological markers			
	Total	NS1 Ag$^+$	IgM$^+$	IgG$^+$
Gender	N (%)	n (%)	n (%)	n (%)
Female	2693 (60.1%)	1365 (50.7%)	863 (32.0%)	1012 (37.6%)
Male	1791 (39.9%)	987 (55.1)	577 (32.2%)	637 (35.6%)
Total	4484 (100.0%)	2352 (52.5%)	1440 (32.1%)	1649 (36.8%)
Age group				
<5 years	287 (6.4%)	139 (48.4%)	103 (35.9%)	96 (34.1%)
5 - 15	824 (18.4%)	451 (54.7%)	260 (31.6%)	286 (34.7%)
16 - 30	1864 (41.6%)	1069 (57.3%)	571 (30.6%)	653 (35.0%)
31 - 45	927 (20.7%)	461 (49.7%)	297 (32.0%)	339 (36.6%)
46 - 65	473 (10.5%)	197 (41.6%)	166 (31.5%)	222 (46.9%)
>65 years	109 (2.4%)	35 (32.1%)	43 (39.4%)	51 (46.8%)

NS1: Non-structural Protein 1, Immunoglobulin M (IgM), Immunoglobulin G (IgG).

3.2. Seroprevalence of Dengue Virus Infection in the Study Population

It is noteworthy that 52.5% (2352/4484) of the study population tested positive for NS1 Ag, 32.1% (1440/4484) for IgM, and 36.8% (1649/4484) for IgG. The age group 16 - 30 years had the highest positivity rates for NS1 Ag (57.3%, 1069/1864) and IgM (30.6%, 571/1864), while the age groups 46 - 65 years and > 65 years showed the highest IgG positivity rates (Table 1).

The overall dengue seroprevalence was 57.5% (2578/4484), with the following specific rates: 37.9% (1701/4484) NS1 Ag$^+$, 18.2% (817/4484) IgM$^+$, 6.9% (309/4484) NS1 Ag$^+$/IgM$^+$, 6.3% (282/4484) NS1 Ag$^+$/IgG$^+$, and 1.3% (60/4484) triple positive (Table 2). Individuals with past infections (positive for IgG only) constituted 23.5% (1053/4484) of the study population.

Multinomial regression analysis revealed that the age group 16 - 30 years was significantly more likely to test positive for NS1 Ag compared to children under five years old (OR = 1.487 [1.158 - 1.911], p = 0.002). Conversely, individuals

above 65 years were significantly less likely to test positive for NS1 Ag compared to the same reference group (OR = 0.517 [0.325 - 0.824], p = 0.005). No significant differences in IgM positivity were observed across sex and age groups (Table 3).

Table 2. Serological profile of dengue virus infection in the study population.

Variables		IgG			
		IgM	Negative	Positive	Total
NS1 Ag	Negative	Negative	8 (0.2%)	1053 (23.5%)	1061 (23.7%)
		Positive	817 (18.2%)	254 (5.7%)	1071 (23.9%)
		Total	825 (18.4%)	1307 (29.1%)	2132 (47.5%)
	Positive	Negative	1701 (37.9,0%)	282 (6.3%)	1983 (44.2%)
		Positive	309 (6.9%)	60 (1.3%)	369 (8.2%)
		Total	2010 (44.8%)	342 (7.6%)	2352 (52.5%)

NS1: Non-structural Protein 1, Immunoglobulin M (IgM), Immunoglobulin G (IgG).

Table 3. Multinomial logistic regression analysis of NS1 antigen and IgM frequencies in the study population.

Characteristics	NS1 Ag$^+$			IgM$^+$		
	NS1 Ag$^+$	IgM$^+$	IgG$^+$			
Gender	OR	CI 95%	p-value	OR	CI 95%	p-value
Female	0.827	[0.732 - 0.934]	0.002	1.000	[0.879 - 1.138]	0.995
Male	Ref.	-	-	Ref.	-	-
Total						
Age group						
<5 years	Ref.	-	-	Ref.	-	-
5 - 15	1.307	[0.998 - 1.711]	0.052	0.823	[0.621 - 1.092]	0.178
16 - 30	1.487	[1.158 - 1.911]	0.002	0.789	[0.607 - 1.025]	0.076
31 - 45	1.088	[0.834 - 1.419]	0.535	0.842	[0.637 - 1.113]	0.227
46 - 65	0.788	[0.586 - 1.060]	0.115	0.966	[0.710- 1.313]	0.825
>65 years	0.517	[0.325 - 0.824]	0.005	1.164	[0.739 - 1.832]	0.513

NS1: Non-structural Protein 1, Immunoglobulin M (IgM), Immunoglobulin G (IgG).

3.3. Evolution of Dengue Virus Infection during the Year

Suspected febrile cases tested for dengue throughout the year showed fewer cases from January to August, with a gradual increase in the proportion of positive cases over the months. NS1 Ag-positive cases accounted for 4.8% (6/126) and 6.9% (5/72) in January and February, respectively. The proportion of positive cases remained below 50% in May (37.0%, 20/54), June (47.8%, 33/69), and July (40.7%, 44/108). However, the percentage of positive cases increased to 70.3% (64/91) in March, 81.4% (57/70) in April, and 56.1% (83/148) in August. Notably, most suspected

cases, 83.5% (3746/4484), were recorded in September, with 54.5% (2040/3746) testing positive for NS1 Ag (Figure 1).

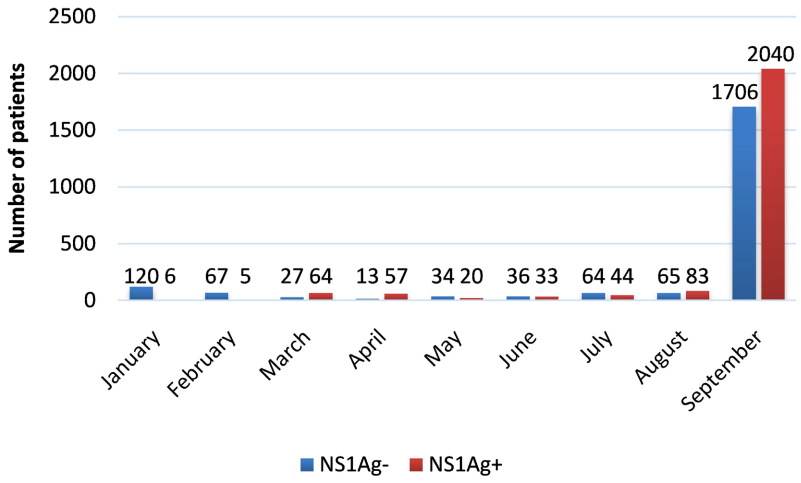

Figure 1. Temporal patterns of dengue infection from January to September 2023.

4. Discussion

In 2023, dengue fever cases reached unprecedented levels globally, with Burkina Faso experiencing one of its most severe outbreaks [15]. The World Health Organization (WHO) reported that Burkina Faso accounted for 85% of the region's reported dengue cases and 91% of related fatalities in 2023 [16]. By December 18, 2023, Burkina Faso had recorded 146,878 suspected dengue cases, including 68,346 probable cases confirmed by rapid diagnostic tests, and 688 deaths among the suspected cases, resulting in a case fatality rate of 0.5% [17]. The findings of the present study provide critical insights into the serological patterns of dengue virus infection among febrile cases in Burkina Faso.

4.1. Sociodemographic Characteristics and Seroprevalence

The study revealed that females accounted for a larger proportion of the study population (60.1%), yet males exhibited slightly higher rates of NS1 antigen positivity (55.1% vs. 50.7%). This pattern has been observed in other studies, where males are often reported to have higher susceptibility or exposure risk due to behavioral and environmental factors, such as outdoor activities that increase contact with Aedes mosquitoes [4] [11] [12] [18]. However, the gender-related differences in dengue prevalence remain inconsistent across studies and may vary depending on local dynamics [10] [19].

The age group 16 - 30 years showed the highest positivity for NS1 antigen (57.3%), indicating active infection, which aligns with literature suggesting that young adults are at a higher risk due to mobility and exposure in urban or peri-urban settings [9] [18]. Similarly, the observed high IgG positivity in older age groups (>46 years) reflects cumulative exposure to dengue virus over time, consistent with studies showing that older populations are more likely to have antibodies due to prior

infections [20]-[22].

4.2. Seroprevalence and Serological Markers

The overall seroprevalence of 57.5% reflects a high burden of dengue in the study population, which is comparable to findings from endemic regions in Asia and Latin America [23] [24]. The dominance of NS1 antigen positivity (52.5%) suggests ongoing transmission, while the significant proportion of IgM-positive cases (32.1%) indicates recent infections. The high rate of IgG positivity (36.8%) reflects both prior exposure and the endemic nature of dengue in the region [4] [6] [25].

Notably, the study identified a substantial number of cases with multiple serological markers, including triple-positive cases (1.3%), which were found to be predictive of severe thrombocytopenia linked to dengue infection and a higher risk of mortality. Such profiles are indicative of either sequential infections with different dengue serotypes or co-circulation of serotypes, which aligns with findings in regions where multiple serotypes are endemic [6] [11] [12]. However, our study did not include laboratory confirmation of circulating serotypes. Incorporating serotype data in future investigations would allow for analysis of their distribution, potential shifts, and possible associations with disease severity and transmission dynamics, thereby improving outbreak preparedness.

4.3. Temporal Patterns of Dengue Infections

Positioning The seasonal dynamics observed in this study, with a significant spike in dengue cases during September (83.5% of cases, with 54.5% NS1 antigen positivity), align with the well-documented correlation between dengue incidence and climatic factors [5] [6]. Increased transmission during rainy seasons is attributed to optimal breeding conditions for Aedes aegypti, the primary vector [25]. The gradual rise in positive cases from January to August, followed by a peak in September, is consistent with the previous studies conducted by our research team, showing that peak of DENV infection in Burkina Faso generally occurred between October and November [4] [11] [12].

The burden of dengue in Burkina Faso, as indicated by this study, is consistent with the increasing incidence of dengue reported globally [17]. African countries, including Burkina Faso, are increasingly contributing to this burden, reflecting expanding geographic transmission due to urbanization, climate change, and inadequate vector control measures [16]. The findings highlight the critical need for enhanced surveillance systems to monitor serotype dynamics and guide targeted interventions. The high seroprevalence underscores the importance of implementing integrated vector management strategies and strengthening diagnostic capacities, particularly for serological markers like NS1, IgM, and IgG, which are pivotal in resource-limited settings.

This study contributes to the growing body of evidence on the epidemiology of

dengue in Africa and underscores the importance of continuous monitoring and intervention strategies. The high prevalence of dengue calls for urgent action to mitigate the impact of future outbreaks through improved surveillance, public health education, and vector control efforts.

4.4. Methodological Considerations and Limitations

Although multinomial regression highlighted demographic patterns (e.g., male sex, young adult age group), potential confounders such as socioeconomic status, access to healthcare, and travel history were not included in the analysis. Their absence may limit interpretation of independent associations. Future studies should incorporate these covariates to better disentangle the effects of demographic and behavioral risk factors.

Other limitations include selection bias, as only patients presenting for testing were included, and possible misclassification due to serological cross-reactivity with other flaviviruses. The cross-sectional design also limits causal inferences and the ability to track temporal changes at the individual level.

4.5. Public Health and Research Implications

The high seroprevalence observed underscores the urgent need for strengthened surveillance systems that integrate serotype monitoring, climatic variables, and vector indices. Public health interventions should prioritize targeted vector control campaigns during peak rainy months, school- and workplace-based awareness programs focusing on young adults and males, and improved diagnostic capacity at primary health facilities. Furthermore, incorporating serotype-specific data into predictive models would allow health authorities to anticipate severe outbreaks linked to shifts in circulating strains. Finally, longitudinal cohort studies with robust sociodemographic and clinical data are essential to clarify the dynamics of infection, immunity, and severity over time.

5. Conclusion

This study revealed a high burden of dengue virus infection among febrile patients tested at CERBA, with an overall seroprevalence of 57.5%. More than half of the study population tested positive for NS1 antigen, indicating active transmission, while nearly one-quarter showed evidence of past infection through IgG positivity. The age group 16 - 30 years was the most affected, highlighting the vulnerability of young adults, while older age groups exhibited higher rates of IgG, reflecting cumulative exposure. Gender analysis showed slightly higher NS1 positivity in males, suggesting possible behavioral or occupational exposure differences. The temporal distribution demonstrated a sharp increase in dengue cases during September, coinciding with the rainy season and optimal vector breeding conditions. Together, these findings emphasize the need for enhanced surveillance, targeted prevention strategies, and timely vector control interventions to mitigate dengue transmission and its impact in Burkina Faso.

Author Contribution

Conceptualization, A. K. O and J. S.; methodology, A. K. O., D. P. I., T. S., A. T. Y., and A. K. Y. A.; software, A. K. O., D. P. I and T. S.; validation, D. P. I., T. S. and J. S.; formal analysis, A. K. O., D. P. I. and T. S.; investigation, A. K. O., D. P. I. and T. S.; resources, A. T. Y., A. K. Y. A. and J. S.; data curation, A. K. O., D. P. I., T. S. and J. S.; writing—original draft preparation, A. K. O., D. P. I. and T. S.; writing—review and editing, A. K. O., D. P. I., T. S., A. T. Y., A. K. Y. A. and J. S.; visualization, D. P. I., T. S., and J. S.; supervision, J. S.; project administration, J. S.; funding acquisition, this research received no external funding.

Ethical Approval

The institutional ethics committee of CERBA approved the protocol for the present study through deliberation N˚2022-15/11-05 on 15 November 2022, guaranteeing the ethical handling and use of patient data.

Conflicts of Interest

The authors declare that they have no conflict of interest.

References

[1] Akinsulie, O.C. and Idris, I. (2024) Global Re-Emergence of Dengue Fever: The Need for a Rapid Response and Surveillance. *The Microbe*, **4**, Article 100107. https://doi.org/10.1016/j.microb.2024.100107

[2] Mercy, K., Youm, E., Aliddeki, D., Faria, N.R., Kebede, Y. and Ndembi, N. (2024) The Looming Threat of Dengue Fever: The Africa Context. *Open Forum Infectious Diseases*, **11**, ofae362.

[3] WHO (2024) Dengue and Severe Dengue. https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue

[4] Bello, S.O.T., Houkpevi, A., Zackari, S., Tapsoba, A.S.A., Zoure, A.A., Ilboudo, P.D., *et al.* (2022) Epidemiology of Dengue in Patients with Febrile Syndrome at Saint Camille Hospital, Ouagadougou, Burkina Faso from 2020 to 2021. *African Journal of Clinical and Experimental Microbiology*, **23**, 398-406. https://doi.org/10.4314/ajcem.v23i4.8

[5] Bello, S.O.T., Tapsoba, A.S.A., Zoure, A.A., Bassole, Y.J.R., Yogo, W.K., Bado, P., *et al.* (2024) Molecular Characterization of the Four Serotypes (DENV-1, DENV-2, DENV-3 and DENV-4) of Dengue Virus Circulating in Ouagadougou, Burkina Faso. *Open Journal of Epidemiology*, **14**, 565-578. https://doi.org/10.4236/ojepi.2024.144040

[6] Ouattara, A.K., Toyin Bello, S.O., Ouédraogo, A., Traoré, L., Djigma, F.W. and Simporé, J. (2024) Predominance of DENV-3 among Patients in Ouagadougou, Burkina Faso. *Journal of Vector Borne Diseases*, **62**, 60-66. https://doi.org/10.4103/jvbd.jvbd_68_24

[7] Gomgnimbou, M.K., Belem, L.R.W., Some, K., Diallo, M., Barro, B., Kaboré, A., *et al.* (2024) Utilization of Novel Molecular Multiplex Methods for the Detection And, Epidemiological Surveillance of Dengue Virus Serotypes and Chikungunya Virus in Burkina Faso, West Africa. *Molecular Biology Reports*, **51**, Article No. 906. https://doi.org/10.1007/s11033-024-09847-1

[8] Mwanyika, G.O., Mboera, L.E.G., Rugarabamu, S., Ngingo, B., Sindato, C., Lutwama, J.J., *et al.* (2021) Dengue Virus Infection and Associated Risk Factors in Africa: A Systematic Review and Meta-Analysis. *Viruses*, **13**, Article 536.

[9] Ouattara, C.A., Traore, S., Sangare, I., Traore, T.I., Meda, Z.C. and Savadogo, L.G.B. (2022) Spatiotemporal Analysis of Dengue Fever in Burkina Faso from 2016 to 2019. *BMC Public Health*, **22**, Article No. 462. https://doi.org/10.1186/s12889-022-12820-x

[10] Ouattara, C.A., Traore, T.I., Ouedraogo, B., Sylla, B., Traore, S., Meda, C.Z., *et al.* (2023) Spatio-Temporal Determinants of Dengue Epidemics in the Central Region of Burkina Faso. *Tropical Medicine and Infectious Disease*, **8**, Article 482.

[11] Ouattara, A.K., Nadembega, C., Diarra, B., Zohoncon, T., Yonli, A., Obiri-Yeboah, D., *et al.* (2017) Serological Diagnosis in Suspected Dengue Cases at Saint Camille Hospital of Ouagadougou: High Prevalence of Infection among Young Adults Aged 15 to 30 Years. *International Journal of Recent Advances in Multidisciplinary Research*, **4**, 3299-3304. https://www.researchgate.net/publication/323019211

[12] Ilboudo, D.P., Zohoncon, T.M., Hien, Y.E., Ouattara, A.K., Traore, L., Ouermi, D., *et al.* (2022) Dengue Immunological Markers Evolution at Saint Camille Hospital in Ouagadougou (HOSCO) Burkina Faso. *Pakistan Journal of Biological Sciences*, **25**, 254-262. https://doi.org/10.3923/pjbs.2022.254.262

[13] Kok, B.H., Lim, H.T., Lim, C.P., Lai, N.S., Leow, C.Y. and Leow, C.H. (2023) Dengue Virus Infection—A Review of Pathogenesis, Vaccines, Diagnosis and Therapy. *Virus Research*, **324**, Article 199018. https://doi.org/10.1016/j.virusres.2022.199018

[14] Dhal, A., Kalyani, T., Ghorai, S., Sahu, N.K. and Jana, S.K. (2020) Recent Development of Electrochemical Immunosensor for the Diagnosis of Dengue Virus NSI Protein: A Review. *Sensors International*, **1**, Article 100030. https://doi.org/10.1016/j.sintl.2020.100030

[15] Manigart, O., Ouedraogo, I., Ouedraogo, H.S., Sow, A. and Lokossou, V.K. (2024) Dengue Epidemic in Burkina Faso: How Can the Response Improve? *The Lancet*, **403**, 434-435. https://doi.org/10.1016/s0140-6736(23)02803-9

[16] WHO (2023) Dengue in the WHO African Region: Situation Report 01: 19 December 2023. https://www.afro.who.int/countries/burkina-faso/publication/dengue-who-african-region-situation-report-01-19-december-2023

[17] WHO (2023) Bulletins d'information sur les flambées épidémiques: Dengue—Situation Mondiale. https://www.who.int/fr/emergencies/disease-outbreak-news/item/2023-DON498

[18] Prasith, N., Keosavanh, O., Phengxay, M., Stone, S., Lewis, H.C., Tsuyuoka, R., *et al.* (2013) Assessment of Gender Distribution in Dengue Surveillance Data, the Lao People's Democratic Republic. *Western Pacific Surveillance and Response Journal*, **4**, 18-25. https://doi.org/10.5365/wpsar.2012.3.4.020

[19] Chakravarti, A., Roy, P., Malik, S., Siddiqui, O. and Thakur, P. (2016) A Study on Gender-Related Differences in Laboratory Characteristics of Dengue Fever. *Indian Journal of Medical Microbiology*, **34**, 82-84. https://doi.org/10.4103/0255-0857.174106

[20] Haider, N., Asaduzzaman, M., Hasan, M.N., Rahman, M., Sharif, A.R., Ashrafi, S.A.A., *et al.* (2023) Bangladesh's 2023 Dengue Outbreak—Age/gender-Related Disparity in Morbidity and Mortality and Geographic Variability of Epidemic Burdens. *International Journal of Infectious Diseases*, **136**, 1-4. https://doi.org/10.1016/j.ijid.2023.08.026

[21] Velandia-Romero, M.L., Coronel-Ruiz, C., Castro-Bonilla, L., Camacho-Ortega, S.,

Calderón-Peláez, M.A., Castellanos, A., *et al.* (2020) Prevalence of Dengue Antibodies in Healthy Children and Adults in Different Colombian Endemic Areas. *International Journal of Infectious Diseases*, **91**, 9-16. https://doi.org/10.1016/j.ijid.2019.10.045

[22] Kumar, A. and Nielsen, A.L. (2015) Trends in the Patterns of IgM and IgG Antibodies in Febrile Persons with Suspected Dengue in Barbados, an English-Speaking Caribbean Country, 2006-2013. *Journal of Infection and Public Health*, **8**, 583-592. https://doi.org/10.1016/j.jiph.2015.05.013

[23] Murhekar, M.V., Kamaraj, P., Kumar, M.S., Khan, S.A., Allam, R.R., Barde, P., *et al.* (2019) Burden of Dengue Infection in India, 2017: A Cross-Sectional Population Based Serosurvey. *The Lancet Global Health*, **7**, e1065-e1073. https://doi.org/10.1016/s2214-109x(19)30250-5

[24] Chiaravalloti-Neto, F., da Silva, R.A., Zini, N., da Silva, G.C.D., da Silva, N.S., Parra, M.C.P., *et al.* (2019) Seroprevalence for Dengue Virus in a Hyperendemic Area and Associated Socioeconomic and Demographic Factors Using a Cross-Sectional Design and a Geostatistical Approach, State of São Paulo, Brazil. *BMC Infectious Diseases*, **19**, Article No. 441. https://doi.org/10.1186/s12879-019-4074-4

[25] Bello, S.O.T., Zoure, A.A., Ouattara, A.K., Somda, D., Nadembega, C., Obiri-Yeboah, D., *et al.* (2024) Geographical Distribution of Arboviruses, aedes Aegypti and aedes Albopictus Vectors and Their Resistance to Insecticides in Africa: A Systematic Review. *Advances in Entomology*, **12**, 249-274. https://doi.org/10.4236/ae.2024.124019